Obs. The structure of the antennæ, as well as their insertion, seems to justify the location of this insect in the Colydiidæ. The anterior coxæ are very small, and their cavities completely closed behind; and this is the only character, so far as I can see, which would throw any doubt on the propriety of the association mentioned. Mr. Wollaston, in calling attention to the peculiarities of this important genus, has already suggested its affinity with the Colydiidæ. The New-Zealand insect I have here described approaches the *Aglycyderes setifer* closely in appearance; but it differs in the structure of the antennæ, as well as in its remarkably widely separated anterior coxæ. The Colydiidæ as a group is one of the less specialized of the Coleopterous groups; and it is not therefore surprising that we should find some of its members exhibiting wide and puzzling affinities. I am unable to see any close relationship in *Aglycyderes* with Bruchidæ and Anthribidæ; and if the genus be not accepted as an aberrant member of the Colydiidæ, I think there is no other course but to do as Mr. Wollaston has suggested, viz. to regard it as representing a distinct family of Coleoptera.

III.—Eozoon canadense, *according to Hahn*.

By J. W. Dawson, LL.D., F.R.S., F.G.S.

We may probably expect, for some time, to find enthusiastic mineralogists suggesting plausible theories to account for *Eozoon* by purely physical causes; for the doctrine of "plastic force" is not yet extinct in this particular case. Hahn's recent memoir is one of these efforts, and is certainly creditable to his ingenuity and boldness, more especially as it is quite at variance with the hypothesis advocated by Messrs. King and Rowney. It is, however, in my judgment, so improbable that, but for the sanction given to it by a translation into the 'Annals,' and for the new statements which it makes as to certain histological facts, it would scarcely merit a serious discussion. Yet it affords an opportunity to notice a number of minor points respecting *Eozoon*, which, though not overlooked by those who have studied it, have not been brought prominently forward, lest they should confuse the minds of geologists as to essential facts.

Hahn's explanation refers only to the specimens of *Eozoon* mineralized with serpentine, the only specimens which he appears to have studied. It does not apply to those mineralized with calcite, Dolomite, Loganite, or pyroxene, except in so far as the cases of these may be supposed to be covered by

the assertion that structures resembling the canal-system of *Eozoon* may be seen in gneissose rocks.

As applied to the ordinary serpentinous specimens, Hahn's theory of their origin may be stated thus :—He agrees with the advocates of the organic nature of *Eozoon* in admitting that the layers of calcite are an original part of the formation. He supposes, however, that the serpentine was originally olivine, which, like serpentine, is a silicate of magnesia, but anhydrous, and differing somewhat in the proportions of its ingredients. The olivine by absorption of water became converted into serpentine, and necessarily swelled to a greater bulk than before*. This expansion caused it to force itself between the layers of limestone and to assume a laminated form. The limestone at the same time became softened and fissured; and its fissures or pores were injected with calcareous matters held in solution or suspension in the water saturating the rock. In this way the laminæ and the canal-system are to be accounted for. The "proper wall" he holds to be merely a film of needles of chrysotile or fibrous serpentine surrounding the grains and plates of that mineral. These views he supports by statements grouped under the three heads of Geological, Mineralogical, and Zoological Facts ; but the two former cannot well be separated from each other, and the latter are, from his point of view, of course altogether subordinate. For the sake of clearness, I may arrange his arguments and my criticisms under the following heads.

1. *Preliminary Assumption.*—Hahn informs us that he "started from the proposition that for every part of a rock the presumption is in favour of mere rock-formation." Surely not, when a definite form visible to the naked eye is in question. In the present case it was the resemblance of the masses of *Eozoon* to the familiar *Stromatoporæ* of the Silurian which first directed attention to them. The microscopist has a right to inquire whether in such a case internal structure confirms the indication of external form, but not to proceed from the assumption of mineral origin, even when the microscope fails to reveal structure. Further, when portions only of such a specimen show organic structure, this is always held to afford evidence of organic nature, even though these portions should be small and exceptional.

2. *Geological Relations.*—As to these, Hahn seems to be in some doubt. He asks—"Are they [the serpentine nodules and layers] merely imbedded in the limestone, and therefore formed before it, or were they produced simultaneously?" and he remarks, "This question can be decided only on the spot." It

* The expansion would be about in the ratio of 4 to 3.

is possible that he may not have read the elaborate reports of Sir W. E. Logan and his assistants on the Laurentian rocks, or even the descriptions of the beds containing *Eozoon* given by Logan, Hunt, and myself. In any case, the question shows want of acquaintance with the actual facts as to the inclusion of the masses and fragments of *Eozoon* in regularly bedded limestones which contain also nodules and layers of serpentine. Had these facts been clearly before his mind, he would probably have adopted some other theory of the origin of *Eozoon*, since it seems physically impossible that regularly bedded and laminated limestones can have suffered such changes as he supposes. The bands and nodules and grains of serpentine, whether with or without the structure of *Eozoon*, present no indications of any such expansion as would have resulted from the conversion of olivine into serpentine. This one consideration might indeed close our case with reference to Hahn's hypothesis, were there not some points of interest in his further statements.

3. *Associated Minerals.*—He seems to be unaware of the elaborate series of microscopic examinations to which I subjected the limestones containing *Eozoon*, and many others more or less resembling them, before the specimens were submitted to Dr. Carpenter. These researches were made with the best instruments, with large series of specimens prepared in the best manner by Mr. Weston, of the Geological Survey, and with the experience of twenty years in observations of this kind, and were aided by the unsurpassed chemical skill of Dr. Sterry Hunt. The whole of the results have not, it is true, been published in detail. Yet he cannot have read the published descriptions of *Eozoon*, and the replies to opponents, without perceiving that large series of facts bearing on the texture and microscopical characters of the serpentine, calcite, Dolomite, Loganite, mica, pyroxene, graphite, pyrite, chondrodite, spinel, and other mineral substances associated with *Eozoon* had been accumulated and recorded. Many of these facts, indeed, seem entirely to have escaped his attention. I may instance the occurrence of crystals of mica in the specimens of *Eozoon*, this being by far the most common accidental mineral present. Perhaps he has confounded its crystals with aragonite and olivine. It is to be observed here that mica is one of the most usual minerals developed in altered fossiliferous rocks. I have observed it in connexion with *Halysites* and Crinoids in the schists of the White Mountains, and with similar fossils of Upper Silurian age in the slates of Lake Memphramagog and the New-Canaan district in Nova Scotia. A still more strange omission is that of the Dolomite which

fills large portions of the canal-system, and which in decalcified specimens shows beautifully its characteristic cleavage and lustre in the casts of the canals.

4. *The Origin of Serpentine.*—"Serpentine," he says, "is not an original, but a metamorphic rock." It may be answered that on both geological and chemical grounds Hunt, Delesse, Credner, and Gümbel arrive at a different conclusion, and that in Silurian and other rocks serpentine itself and allied silicates, like glauconite, iollyte, &c., occur as fillings of the cavities of fossils. With regard to the *Eozoon*-serpentine, however, he believes that it is a product of the alteration of olivine. He does not explicitly assert the occurrence of olivine in the Canadian serpentines, but bases his assertion on certain other specimens not Canadian, and on the appearance of fissures and colours akin to those of olivine in some parts of the Canadian specimens. In point of fact, as Dr. Hunt has shown, olivine does occur in some Canadian serpentines of Huronian or Silurian age, but not, so far as ascertained here, in those of the Laurentian system, in which the large proportion of water indicated on analysis shows that this anhydrous silicate cannot be present in any appreciable quantity. Independently of this consideration, as olivine is a mineral having a hardness of 6·5 to 7, or nearly twice that of serpentine, if present in any of the numerous specimens sliced and polished by Mr. Weston and myself, it could scarcely have escaped our observation. In these circumstances I must regard Hahn's determination from polariscope characters as quite uncertain. Besides, I am familiar with the optical characters of olivine, and know that serpentine often very closely resembles it. Further, with reference to the alleged metamorphosis of olivine into serpentine, it must be borne in mind that olivine contains more of magnesia and other bases and less of silica than serpentine, so that the mere addition of water could not suffice to effect this change. As Dr. Hunt suggests to me, the removal of a considerable part of the magnesia would be necessary; and this could scarcely have been effected except by carbon dioxide, which would have acted by preference on the surrounding limestone. Still further, as Scheerer long ago objected, in the case of the Snarum serpentine, the expansion consequent on the conversion of olivine into serpentine would have broken up all the surrounding minerals. In the case of the Canadian serpentine we have not only an absence of disturbance, but the serpentine has actually become shrunken and has had its fissures filled with chrysotile.

But the conclusive facts with reference to the ordinary aqueous origin of serpentine remain to be stated. In those

formations in Canada referred by Sir William Logan to the Quebec group, there occur serpentines enclosing and filling the cavities of ordinary palæozoic fossils. These serpentines were mentioned in connexion with *Eozoon* in my early papers in the 'Geological Journal,' because I had examined slices of them in the course of my studies of the Laurentian specimens; but much larger series of slices, prepared by Mr. Weston to illustrate Sir William Logan's later researches in these rocks (unhappily left unfinished at the time of his death), have recently been placed in my hands. In specimens of ophiolite from Melbourne I find the dark green serpentine of that locality not only enveloping fragments of shells, Crinoids, and corals, but penetrating their pores and cavities. In another specimen collected by Mr. Richardson at Le Chibogomon, in a great bed of olive-green serpentine, which has been analyzed by Hunt, there is a specimen of a tabulate coral quite large enough to be seen distinctly with the naked eye, having many of its thin-walled hexagonal cells filled with serpentine, while others are filled with calcite. These facts, of which I hope details will shortly be published, effectually dispose of Hahn's difficulties as to serpentine filling the cavities of fossils.

I may add that the question whether chondrodite (which does occur in the Laurentian limestones) may have been a source of serpentine has been discussed by Dr. Hunt, and answered in the negative, and that Gümbel has found unaltered chondrodite filling cavities of *Eozoon**. Some of these points in relation to the Laurentian serpentines of Canada have been fully discussed by Dr. Hunt as far back as 1853, in his memoir on the Constitution of Mineral Species, in Silliman's Journal for that year.

5. *The Laminæ of* Eozoon.—Hahn says that "the calcareous layers occur in serpentine rocks which contain no *Eozoon canadense*." This of course no one denies; but its terms betray a curious misconception. In the case of *Eozoon* it is the serpentine layers that are included in the limestone, not the limestone in the serpentine. Further, the serpentine layers are limited to certain definite forms, and have no more resemblance to ordinary rock-lamination than have the layers of *Stromatoporæ* or fossil trunks of trees. I have examined numerous laminated serpentines and ophiolites, as well as laminated rocks and concretions of other kinds, some of which have indeed been sent to me for examination by collectors, who supposed that they might be allied to *Eozoon*; but I have not, even in the case of small fragments, experienced any

* Memoir on Laurentian Rocks of Bavaria, 1866.

difficulty in distinguishing these from the limited, tuberculated, and Stromatoporoid chamber-casts of *Eozoon*.

6. *The Canal-system.*—I am not quite certain how Hahn regards this. To accord with his expansion theory, the canals should be mere cracks or fissures; and in one place he describes them as such, though they are in reality cylindrical in form. In another place he speaks of them as produced by the injection of a fluid containing lime in solution into a more dense fluid or semifluid substance. He objects to their being of different dimensions, though this is a necessary result of their ramifying into small branches. In regard to their composition, he seems to state that they are entirely soluble in dilute acid, and speaks of them as originating in crystals of aragonite—though the fact is that large portions of them remain intact in specimens treated with dilute acid, as he must have himself observed. He appears also to suppose that they should show a "tube or envelope"—which is not at all necessary, since, according to the organic theory of *Eozoon*, they were originally merely ramifying perforations in a calcareous skeleton. In point of fact, in the ordinary serpentinous specimens the chambers and chamberlets are in part filled with a flocculent or porous serpentine, white by reflected light and brown by transmitted light; and this fills the larger canals; but the finer branches of these canals are often filled with calcite or Dolomite. This mode of filling, which has been fully illustrated by Dr. Carpenter and myself, does not, however, at all suit the requirements of the olivine and expansion theory.

He has, however, made the observation, for which he deserves some credit, that "a canal-system does not generally extend beyond one crystalline individual." There is an element of truth in this, though it is not strictly correct. The canal-systems are in general related to definite portions or thickenings of the supplemental skeleton. These may often be called in a certain sense crystalline individuals, their cleavage-planes being uniform in direction. But otherwise it is not usual to find the canals ceasing at interruptions of the crystalline structure, except in certain easily explicable cases. It is observable, for instance, that the perfection of the structures and of the crystallization are often in inverse ratio. Thus in portions where the skeleton retains its granular character (regarded apparently by Hahn as a "fluidal structure")* the canals are

* The skeleton of *Eozoon* in its natural state seems to have been finely porous, like that of *Stromatopora*, but on a more minute scale. This gives it a granular structure, often very distinct; and in the Burgess specimens the pores seem to have been filled with Dolomite, which remains as a flocculent mass after the calcite has been removed by dilute

more perfect than where the skeleton is transparent cleavable calcite; and where the cleavage-planes become very distinct the canal-system has apparently in some places been altogether obliterated. Again, when the large trunks of the canals are filled with serpentine, and the finer branches with Dolomite or calcite, the serpentine sometimes ends abruptly, as if cut off. In those beds which contain angular fragments of *Eozoon*, the canals of course end at the limits of such fragments. Cases of these kinds account for this appearance in the instances in which it is observed. But if the canals did happen, without any such peculiar circumstances, to be limited by crystalline forms, this would only be an example of a fact familiar to every one experienced in examining fossils under the microscope. I have now before me a slice of crinoidal Trenton limestone in which the fragments of Crinoids show perfectly their cellular structure; but each fragment is inscribed in a hexagonal or rhombic crystal of transparent calcite, so that the structure may be said in every case to be limited by a crystalline individual. I have another specimen of a crinoid from the altered rocks of the White Mountains, in which each joint has the cleavage proper to a crystalline individual, and the minute structures are preserved only in small spots here and there. I have many specimens of calcified coniferous wood from the Coal Formation in which the whole substance consists of cleavable calcite crystals; and yet in some portions the structures are completely preserved, though in places they end abruptly and mysteriously at the edges or in certain parts of the length of crystalline individuals. I might cite many other illustrations; and such cases are familiar to microscopists.

As to the minute prismatic crystals of carbonate of lime sometimes seen to be imbedded in the calcite of the skeleton of *Eozoon*, and which Hahn regards as aragonite (though they are certainly sometimes seen to be traversed by cleavage-planes like those of calcite), these have no definite relation to the canals, among or beside which they lie just as any other imbedded minerals would do. They are evidently merely portions of the calcareous matter which for some reason have crystallized differently from the rest; and possibly in some cases proximity to the canals may have been one determining cause of their formation.

7. *The tubulated Proper Wall.*—This Hahn is content to

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acid. A practised eye can detect the peculiar granulation of the foraminiferal skeleton even in fragments scattered through inorganic limestone or Dolomite, and when the other structures may not be perceptible.

confound with the veins of chrysotile or fibrous serpentine which traverse the specimens, or with fringes of fibrous crystals at the margins of the grains and plates of serpentine. Yet I can testify that the difference between the cell-wall, when properly preserved, and any vein of crystalline mineral is as great as between the tubulated shell of a Brachiopod or a worm and the prismatic shell of a *Pinna* or *Inoceramus*. Further, under polarized light the chrysotile veins have a brilliancy altogether wanting in the proper wall; and I have shown that the chrysotile is of subsequent origin to the cell-wall, and forms true veins traversing all the structures of the masses of *Eozoon*, and passing through the containing rocks. I am not, however, surprised at this confusion, as I have often had occasion to observe the similarity at first sight of things so unlike as sections of crystals of mica, of veins of satin-spar, and of shells of mollusks, crustaceans, and Nummulites. But the existence of the chrysotile veins themselves or of the supposed fringes of serpentine crystals is almost as inexplicable on Hahn's theory as that of the organic cell-wall itself.

Supposed Prejudices of Zoologists.—Both at the beginning and end of his paper Hahn takes occasion to refer to the prepossessions of zoologists, and their inexperience in examining mineral substances, and even hints at their being likely to mistake the crystals in the pitchstone of Arran for organic forms. He forgets that there are now many observers familiar not only with the structures of all kinds of animal and vegetable fossils, but with mineral substances as well. In the case of the canals and tubuli of *Eozoon*, I may merely mention the several kinds of mineral or organic structures which I have found to be capable of misleading unpractised observers, and all of which have actually been compared carefully with this ancient fossil. They may be arranged under the following heads:—(1) Dendritic crystallizations, as those of oxides of iron and manganese in moss-agates and in calcite &c., of native copper and silver in calcite veinstones, and of mica in certain felspars. (2) Coralloidal and vermicular crystallizations, as those of aragonite, Dolomite, and of vermicular mica. (3) Radiating and fibrous crystallizations, as those of satin-spar, of oolitic grains and other concretions, and of tremolite in limestones, and the very similar structures which are found in the shells of *Inocerami* and other mollusks. (4) Microscopic cracks, such as occur in mineral substances which have been affected with shrinkage, which has permitted their fissures to be filled with different substances of later origin; or minute segregation-veins, such as occur in masses of heterogeneous mineral matter: these fissure-veins are often beautifully deve-

loped in serpentine. (5) Crystalline cavities, fluid-cavities, &c., in minerals, which, when carefully studied, show a definite relation to the crystallization, quite different from the canals of *Eozoon*. (6) Fibrous vegetable and animal substances, as the fibres of *Vaucheria* sometimes beautifully preserved in moss-agates, the fibrous structure of sponges and of certain zoophytes. (7) Porous shells and crusts. More especially I have found the shells of *Serpulæ*, of certain Brachiopods, of *Hyolithes*, of Trilobites, and of certain parts of crinoids to present, when injected with mineral substances, appearances very similar to that of *Eozoon* and other Foraminifera. All of these and other mineral and organic structures have actually, in the progress of the researches on *Eozoon*, been under examination; and my own collection contains slices and other preparations of them, accumulated for this special purpose. No doubt, after all this care, mistakes may be made; but I think it right to mention the precautions which have actually been taken, before launching the doctrine of Laurentian life on an incredulous world.

In conclusion, while I must regard Hahn as deserving of some blame for his want of attention to the labours of others, and for the partial and limited way in which he regards the subject, he deserves credit for the minuteness with which he has examined the particular specimens which he has studied; and I trust that when his information as to facts shall have become more complete, his theoretical views will be very much modified.

Postscript.

Since mailing the above communication, I have received the May number of the 'Annals,' containing the second Review with which its correspondents have honoured my little book 'The Dawn of Life.' This review does not, however, induce me to modify any thing I have stated above, nor does it require any detailed reply in the interest of scientific truth, since, though sufficiently rich in personal references, it contains no new facts of any importance to the discussion, and the want of fairness in its treatment of the book will be sufficiently apparent to any one who has the work to refer to. Should my book have the good fortune to go into a second edition, I shall endeavour to give the review such attention as it deserves. In the mean time I am devoting the few hours I can spare for such work to a reexamination of the Palæozoic serpentines and ophiolites of this country, with the view of illustrating the precise conditions under which corals and other familiar fossils occur in these rocks; and the facts thus obtained may perhaps furnish

the best answers to what may be called the "pseudomorphic" objections to *Eozoon*.

It may, however, be useful to notice the few points raised in the "Supplementary Note," as these refer to my recent paper in the Journal of the Geological Society. (1) In this, as well as at page 368, your correspondents appear to object to the canals filled with Dolomite as exceptional, though it is not easy to understand the meaning of the statement by which they endeavour to reconcile this Dolomite-filling with their theory of the formation of the canal-system by the "erosion or decretion of portions of serpentine." I may explain that this kind of filling is not at all rare in the specimens from Petite Nation. I have now in my cabinet at least thirty preparations of this kind, decalcified to show the canals, besides others as slices, and many which I have prepared but have not preserved. Of course I could not figure more than a few; but I did not intend to convey the impression that this appearance is very rare at the locality in question. (2) They absurdly, perhaps in jest, claim me as a disciple of their theory of pseudomorphism, because I have described a specimen, the only one I have yet met with, in which the skeleton is in part "replaced" with serpentine; but such replacement is of course no more pseudomorphism than that which occurs when corals, shells, or wood are replaced with quartz or pyrite. (3) As to the "chevron arrangement," I think I have stated clearly enough that this is not in accordance with my observation; and I cited Mr. Weston as one who has prepared and examined more specimens than any other person. Both of us have the impression that the tubuli of the cell-wall are somewhat uniform in length, and the cell-wall itself parallel-sided, except where affected by flexures and microscopic faults. But on this subject your correspondents may, I have no doubt, obtain Mr. Weston's direct testimony, if they desire it. It is no doubt true that decalcified specimens of the cell-wall often have a ragged and imperfect appearance; but this is due to the great difficulty of preserving such delicate fibres intact; and this is a sufficient reason for my preference of very thin slices as the best means of exhibiting this structure. I may add that I think no one who has seen under polarized light such specimens as those figured in plate viii. figs. 1 to 3 of 'The Dawn of Life,' or plate x. fig. 3 of my paper in the Journal of the Geological Society, could for a moment doubt the fundamental difference of the proper wall and chrysotile veins.

May 27, 1876. J. W. D.